# RECENT PROGRESS AND ISSUES IN PERPENDICULAR MAGNETIC RECORDING

Yoshihisa Nakamura
Research Institute of Electrical Communication, Tohoku University
1-1, Katahira 2-chome, Aoba-ku, Sendai 980-8577, Japan

In 1996, it was pointed out that perpendicular magnetic recording (PMR) using a single-pole type (SPT) head has several faults such as a head-induced erasure (HIE) due to the SPT head [1]. However we are still continuing our research into PMR combined with a double-layered (DL) medium having a soft magnetic backing-layer (BL), because we have obtained several outstanding recording performances as shown in Fig. 1. This paper will describe the main progress made lately and several issues that still remain to be addressed to realize PMR hard disk drives.

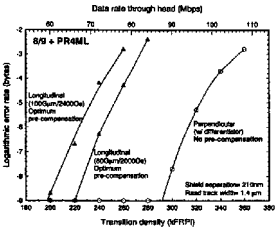


Fig.1 Error rate performance in PMR with a SPT head and a DL medium by an AMR read head.

## Head/media combination

The transition width in PMR is determined by the gradients of both the head field and the mediums MH loop around Hc [2]. The field gradient of a SPT head with a DL medium has a large maximum gradient around the trailing edge of the main-pole. A similar field profile is also obtained from a ring type (RT) thin film head with a DL medium around the trailing edge of the upper pole. However, for a RT head with a SL medium, the gradient around the trailing edge of the gap is small. Therefore, higher recording resolution will be obtained by recording onto a DL medium with a SPT or a RT thin film head. In recording onto a SL medium, the mediums MH loop should have an extremely high gradient around Hc in order to avoid a serious recording demagnetization.

## SPT Write head

We have made a novel SPT flying thin film head, which may have the ideal structure [3]. The coil consists of only one or two turns of thin film conductors around the tip of the main-pole, so that it has a very low self-inductance of about 1 nH up to 1 GHz. However, sufficient O/W characteristics below -30 dB have been obtained at a similar write current to that of a RT thin film head in longitudinal magnetic recording (LMR). This means that the writing field of a SPT head is strong throughout the whole recording layer of DL media. By using this head with a main-pole thickness of 400 nm for writing and a conventional AMR head with a shield gap length of 210 nm for reading, we have observed an isolated pulse of 130 nm in width and a byte error rate below $10^{-7}$ at 300 kFCI (Fig.1) [3]. In the measurements, a differential circuit was used to change the step-like isolated pulse in PMR to a single-peak pulse suitable for a PR4ML channel.

## Media noise

Media noise in PMR is still large in comparison with that in LMR. To obtain a sufficient error rate at a higher bit density, media noise should be decreased drastically. The origin of media noise in PMR is presumed to be due to inverse magnetic domains in the DC erased region [4]. Recently it has been made clear that media noise can be decreased when the squareness of the recording layer is made so as to be S=1 [5]. This means that a strong anisotropy and a moderate exchange interaction should be required for PMR media. In MR head reading, moreover, the noise will be caused by very small fluctuations of the perpendicular component of magnetic flux on the mediums surface. Therefore, media should be made more carefully and perfectly from a viewpoint of the micro magnetic structure.

## Head induced erasure

A small amount of thermal decay occurs in PMR at lower bit densities when the magnetic anisotroply is weak and the dispersion of particles is wide, but it hardly occur at higher bit densities. On the other hanl, HIE is very serious when a SPT head is combined with a DL medium. We have found that the structure of a SPT head and the permeability of the BL in DL media are important parameters for preventing HIE [3]. The novel SPT thin film head mentioned above and a Fe-Si-Al BL of DL media having a relatively high Hc have showed much smaller HIE in external fields exceeding 20 Oe.

In conclusion, although several technical problems still remain in PMR, the prospects for ultrahigh bit density storage using PMR look bright. Low noise media preparation techniques will hold the key to the practical use of PMR.

## References

[1] W. Cain, A. Payne, M. Baldwinson and R. Hampsted, *IEEE Trans. Magn.*, **32**, 97(1995).
[2] Y. Nakamura, *Jour. Mag. Soc. Jpn.*, **21**, Supple. 125(1997).
[3] H. Muraoka, K. Sato, Y. Sugita and Y. Nakamura, *IEEE Trans. Magn*, **35**, (to be published) (1999).
[4] H. Muraoka, S. Yamamoto and Y. Nakamura, *Jour. Mag. Mag. Mat.*, **120**, 323(1993).
[5] N. Honda, J. Ariake and K. Ouchi, *IEEE Trans. Magn*, **34**, 1651(1998).

Yoshihisa Nakamura
Research Institute of Electrical Communication, Tohoku University
2-1-1, Katahira, Aoba-ku, Sendai, 980-8577, Japan
Tel : +81-22-217-5493
Fax : +81-22-217-5496
Email : nakamura@ricc.tohoku.ac.jp

0-7803-5555-5/99/$10.00 ©1999IEEE.